1.1 Water: An Essential Abiotic Factor

Figure D1.2: Fishing in a fast-flowing stream is enjoyable.

Have you ever had the opportunity to go fishing? If you have, can you recall the excitement of catching your first fish? If you are like most people, your first time fishing was in the company of an experienced person who knew the area and important details about the type of fish that you were trying to catch. These included preferred foods and feeding habits.

This information is vital when trying to catch fish. A biologist might say that your fishing success depends upon your knowledge of both **biotic** and **abiotic** factors in the environment of the fish. In other words, if you want to catch fish, you need to have some understanding of the local **ecosystem**.

- biotic factor: a living organism in the environment
- abiotic factor: a physical, non-living part of the environment
- ecosystem: all the organisms in an area as well as the abiotic factors with which they interact

Practice

Use the following information to help you answer questions 1 to 3.

Figure D1.3: Using flies like these increases the probability of anglers catching fish.

These artificial imitations of winged insects float on the water and act as fish bait. They are commonly called flies. The appearance and motion of these flies along the water's surface mimic stranded insects that are a common food source for many fish.

1. Before fishing in a newly discovered mountain stream, an avid angler uses a butterfly net to collect samples of the local airborne insects that are likely to find their way to the stream's surface. The angler then examines these insects and selects the flies to be used for that particular stream. Determine if the angler is assessing the biotic or the abiotic factors of the ecosystem containing the stream when collecting the local insects.
2. Many streams are shaded by trees that grow close to the water's edge. Branches extend over the stream.
   a. Determine if the trees are a biotic factor or an abiotic factor in the stream's ecosystem.
   b. One effect of the shade cast by trees is to reduce the amount of water being heated by direct sunlight. Determine if the water temperature is a biotic factor or an abiotic factor in the stream ecosystem.
   c. Is it possible for an organism to change abiotic factors within an ecosystem?
3. An angler decides that the fish prefer to feed in cooler water shaded from direct sunlight. A particular fly is chosen, and the fishing rod is used to place the fly in an ideal spot. Concisely explain how this demonstrates the angler's understanding of the stream ecosystem.

Perhaps the most important abiotic factor in the mountain stream's environment is the water itself. The water is not just found in the stream—it is an essential component of every life form in the ecosystem. Water comprises 70% to 95% of all cells. Why is water so important? In previous science courses you learned that water is the solvent of life—many ionic components are dissolved in water and are transported between living cells in fluids, such as blood and tree sap. As you learn about other abiotic factors, keep in mind that there are usually connections between these factors and water.

Habitat

How often would you need to water the plants in Figure D1.4? The answer depends entirely on the particular plants you are growing. Petunias thrive in moist soils, whereas begonias need to be watered carefully—too much water will cause their roots to rot. This is why begonias have to be planted in well-drained soil.

Similarly, if you were to ask about the ideal temperature range, the optimum amount of sunlight, the soil composition, or any other abiotic factor, the answers would depend upon what species you were trying to grow. Petunias, for example, grow very well in sunny locations. Begonias prefer shade. Some gardeners have favourite varieties, and they work very hard to provide the optimum conditions to help these plants grow. Other gardeners take a slightly different approach. They begin with the abiotic factors naturally present in the garden site and then select varieties that will thrive in these pre-existing conditions. No matter which approach you take, the idea is to match a plant to its ideal **habitat**. Notice that the description of an ideal habitat is specific to a particular organism.

habitat: all the biotic and abiotic factors present in an area that encourage the reproduction and survival of a particular organism

Figure D1.4: The amount of water and heat that plants receive is crucial.

Practice

4. Describe some characteristics of the ideal habitat for begonias.
5. Describe some characteristics of the ideal habitat for petunias.
6. Identify the advantage in terms of habitat for growing plants in their own containers, such as pots and planters, as opposed to planting them directly into the ground.

One group of abiotic factors that many gardeners attempt to address through the use of fertilizers is the **nutrients** essential for healthy plant growth. Although the nutrients supplied by fertilizers are designed to enhance plant growth and development, these same nutrients can have adverse effects if the fertilizer is applied incorrectly. The most common error is that too much fertilizer is initially applied followed by days of insufficient watering. This leads to a situation where the concentration of the ionic compounds from the fertilizer, often referred to as salts, becomes too high. In the next investigation you will examine the effect of one salt, NaCl(s), on seed germination.

Your body fluids have a similar salt concentration to the water found in oceans. However, if you drink salt water from the oceans, you might die from an overdose of salt.

nutrient: any element or compound that an organism needs for metabolism, growth, or other functioning

Investigation

The Effect of Salinity on Seed Germination

Purpose

The concentration of salt in the soil—often called salinity—is an abiotic factor that affects the ability of plants to grow. You will examine the effect of salinity on the ability of seeds to sprout or germinate. For this activity, a seed is considered to germinate if a stalk or root more than 1 cm long protrudes from the seed.

Materials

- seeds from two different varieties of plants (beans and sunflowers)
- 14 sealable, plastic sandwich bags
- cotton batting or paper towels
- dropper bottles containing the seven solutions
- felt-tipped pen with permanent ink

Science Skills

- ✓ Performing and Recording
- ✓ Analyzing and Interpreting
- ✓ Communication and Teamwork

Procedure

step 1: Help to prepare the following stock solutions for your class:

- distilled water with no salt added (the control)
- 0.25 g of salt per 1 L of distilled water
- 0.50 g of salt per 1 L of distilled water
- 1.0 g of salt per 1 L of distilled water
- 2.0 g of salt per 1 L of distilled water
- 4.0 g of salt per 1 L of distilled water
- 8.0 g of salt per 1 L of distilled water

step 2: Label two plastic bags with the concentration for each of the seven solutions. There will be 14 total bags. One set will be for the bean seeds and the other set for the sunflower seeds.

step 3: Add the cotton batting and five seeds to each plastic bag.

step 4: Add just enough of the corresponding solution into each labelled plastic bag to moisten both the seeds and the cotton batting. Ensure that the volume of solution added to each bag is kept constant.

step 5: Place the seeds in a well-lit location, although this doesn't have to be direct sunlight.

step 6: Every two days, count how many seeds have germinated and add more of each solution if the seeds look dry.

step 7: Repeat step 6 for about two weeks. When you check for the final time, count the number of germinated seeds in each plastic bag.

Analysis

1. Calculate the ratio of germinated seeds to non-germinated seeds for each plastic bag. The germination ratio is equal to the number of seeds that germinated divided by the total number of seeds in each bag. This is then multiplied by 100%. Record your results in a suitable data table.
2. Construct a bar graph to display your results for each plastic bag of seeds. Place the percentage of germinated seeds on the vertical axis and the concentration of the salt solution used to moisten the seeds on the horizontal axis.

3. State what abiotic factor was tested in this experiment. Describe the biotic response affected by the abiotic factor being tested.
4. Compare the germination percentages for the two types of seeds in their responses to the salt solution. Identify any similarities or differences.
5. Compare your findings to those of your classmates. At what level of salinity was the germination of each type of seed affected by the salt's presence?

Extension

6. In many arid countries, increasing soil salinity is creating major problems because once productive land becomes too saline, it is no longer useful for agriculture. One source estimates that about three hectares of arable land is lost every minute due to soil salinity. Use the Internet to determine the main causes of soil salinity in arid countries.

Run-off and Harmful Algal Blooms

Figure D1.5: Fertilizer helps restore nutrients used by plants.

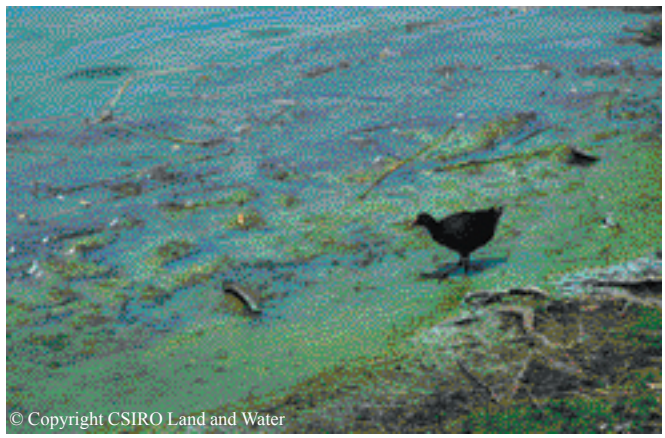


Figure D1.6: A harmful algal bloom can be devastating for other organisms.

Earlier you read that water is the solvent of life. In cases where there is excessive run-off from farmers' fields, nutrients dissolved in the water can have unintended effects on nearby bodies of water.

- algae: microscopic, photosynthetic organisms that play a vital role in marine and freshwater ecosystems
- harmful algal bloom: a rapid growth of algae that can deplete the oxygen dissolved in the water and block the sunlight required by other organisms in the aquatic ecosystem

Decomposers break down decaying organic matter, naturally adding nutrients to the soil. As is the case with gardeners and their potted plants, farmers often supply additional nutrients to soil by using fertilizers. Fertilizers are materials that help restore nutrients used by plants or provide essential nutrients to increase soil productivity. Adding fertilizers containing nitrogen and phosphates can double the yield of wheat and barley grown in nutrient-depleted soil.

If excess fertilizer is carried away from the soil by run-off into local streams and lakes, nutrients from the fertilizer can stimulate the growth of **algae**, leading to a population explosion. The individual alga, which are normally invisible to the naked eye, now form huge colonies and appear as mats of thick, green ooze. When this situation begins to have negative effects on other organisms, it is called a **harmful algal bloom**.

When the population explosion of algae has eventually depleted the nutrients that triggered this event, the algae begin to die in great numbers. The decomposition of dead algae requires oxygen and leads to a reduction in dissolved oxygen in the water. This reduction in dissolved oxygen will have a negative effect on the aquatic life found in the aquatic ecosystem.

Practice

7. Explain the following statement: An effort intended to enhance the abiotic factors in a farmer's field may have negative impacts on both the biotic and abiotic factors essential to a nearby aquatic ecosystem.
8. Some types of algae associated with an algal bloom may create toxins that can taint the water. This leaves it unsuitable for drinking by either humans or livestock. Explain how this situation might adversely affect a farmer whose land borders the body of water with the algal bloom.

Water: A Finite Resource

The central role of water in living systems makes it a precious commodity. Unfortunately, the impact of human activities on the environment is reducing the supply of clean water, while at the same time a growing population is placing demands for increased water use. Water is finally being appreciated as a valuable resource that must be used wisely. Some practices that were considered acceptable many years ago are now being reconsidered. One such practice is the removal of petroleum products from the ground using fresh surface water.

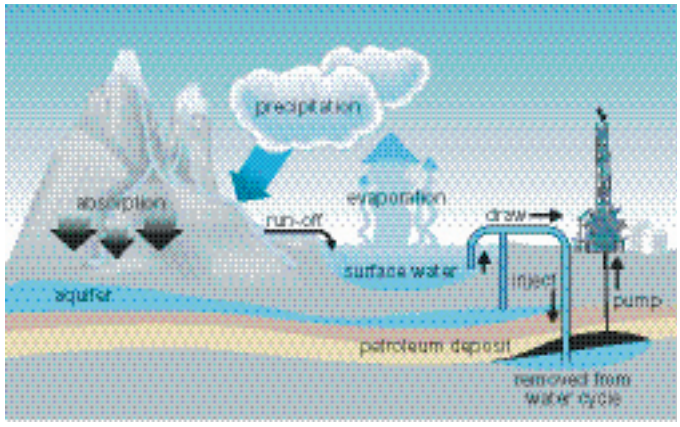


Figure D1.7: The natural water cycle is disrupted by the oil industry's oilfield injection process.

When a well is first drilled, pressure within the reserve is often sufficient to bring petroleum to the surface. As the pressure drops, pumping becomes necessary. Once the pressure drops further, water is often pumped into the well in a process called oilfield injection. Water pumped down into the well creates higher pressures—this allows some of the remaining petroleum to be pumped to the surface. By the time the well is finally shut down, water pumped into the well remains underground permanently and is removed from the hydrological cycle.

Because of the cost, some petroleum companies obtain water for oilfield injection from streams, rivers, and lakes near the well site, rather than utilizing supplies of water unfit for human consumption. Why would the use of fresh water by the petroleum industry be a major concern for residents who live near a petroleum field? In the next investigation you will consider the implications of oilfield injections that use fresh surface water.

Investigation

Take a Stand: Using Fresh Water for Petroleum Extraction

Background

Science Skills

- ✓ Performing and Recording
- ✓ Analyzing and Interpreting
- ✓ Communication and Teamwork

The extraction of fossil fuels is an important component of Alberta's economy. Many petroleum companies inject fresh surface water into their wells to extract petroleum from the ground. When drilling, companies have traditionally used water from the closest or most accessible source, including sloughs, lakes, streams, rivers, and underground aquifers. There are environmental and economic factors that influence the use of nearby freshwater sources in wells. You will use the "Decision-Making Skills and Risk-Benefit Analysis" on pages 548 and 549 to evaluate the use of fresh water to extract petroleum from the ground.

Identifying Alternatives/Perspectives

Using local sources of fresh water by petroleum companies to extract petroleum is controversial. After fresh water is injected into a well, this water is permanently removed from the hydrological cycle. Further, the water is contaminated through contact with the petroleum and cannot be used by living things.

Should companies be allowed to use fresh water to help extract petroleum from the ground? There are many viewpoints to consider while answering this question. These views include those of local residents, environmentalists, local governments, and petroleum companies. By working in teams, you will consider the implications of allowing petroleum companies to use local sources of fresh water by representing each of these viewpoints. Create a chart that concisely summarizes the overall perspectives of each stakeholder group.

Researching the Issue

Each member of your team will research the impact of using fresh water to extract petroleum from wells from the point of view of one stakeholder. For each stakeholder, you should develop at least two distinct arguments to support the overall perspective of that group. Your arguments should be supported by research. Make sure you gather information from a wide variety of sources—newspapers, magazines, scientific journals, the Internet, and other available resources.

Analyzing the Issue

Following a thorough study of available information sources, evaluate the data your team has collected. Analyze the information by placing the arguments in two columns: Arguments for Using Fresh Water for Oilfield Injection and Arguments Against Using Fresh Water for Oilfield Injection. Carefully examine your chart. What assumptions have been made regarding the issue? Are there viable options to avoid using local freshwater sources to extract petroleum?

Take a Stand and Defend Your Position

Using the information summarized in your analysis chart, what is your response to the following issue statement, "Should companies be allowed to use fresh water to help extract petroleum from the ground?"

Consider what your team discovered during your research. Each member of your team should present an answer to the question in the form of a letter to the editor of your local newspaper. Limit your response to a single page. Make sure you refer to your research.

Figure D1.8: Oil rigs use large quantities of water.

Evaluation

1. What were your initial impressions about the issue? How has your perspective changed after exploring the issue?
2. How did you make your decision? What are the likely short-term and long-term effects of your decision?

Extension

3. Use the following information to answer questions 3.a. and 3.b.

The use of fresh water by the petroleum industry is not limited to the process of oilfield injection in wells. Only about 19% of Alberta's oil sands can be surface mined. A method known as in situ bitumen extraction uses large amounts of water to generate steam, which is pumped into the earth to allow the bitumen to be moved up to the surface. This process involves recycling the water, but some water still remains in the oil-sands formation. One estimate is that there is a net loss of one barrel of water for every 50 barrels of petroleum recovered.

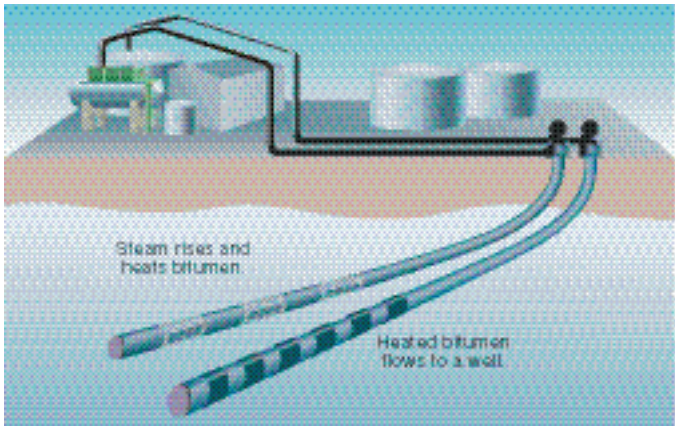


Figure D1.9: The in situ bitumen process is pictured.

a. Suppose the amount of petroleum extracted each day from the in situ bitumen extraction method is about 500 000 barrels. Approximately how much water would be removed daily from the water cycle to process this amount of petroleum? Note that one barrel of petroleum has a volume of 159 L.

b. Use the Internet to determine the latest findings on the environmental impact of removing this water from the ecosystems around Fort McMurray and Cold Lake.

1.1 Summary

Abiotic factors are the non-living components of an ecosystem that influence organisms in the ecosystem. Examples of non-living components include the amount of sunlight and precipitation, the average temperature, and the amount of nutrients found in soil. As you observed with seeds germinating in salt water, any changes to the abiotic factors of an ecosystem may lead to significant changes in the habitat of particular organisms.

This also demonstrates how important it is to carefully consider the use of water. Water, the solvent of life, is perhaps one of the most important abiotic factors because of the central role water plays in living systems.

1.1 Questions

Knowledge

1. Define each of the following.

a. abiotic factor **b.** ecosystem **c.** habitat

Applying Concepts

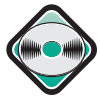
2. Identify three abiotic factors that have a major impact on agricultural crops. Describe the importance of these factors to the crops' growth. Describe actions taken by farmers to ensure that these abiotic factors required by crops are provided.

3. Identify two abiotic factors that also describe a region's climate.

4. Describe how a harmful algal bloom affects the aquatic life found in a body of water.

5. Water is an important component of any ecosystem. The usage of water by individuals varies by location. The average Canadian uses 326 L of water per day. A person living in sub-Saharan Africa uses only 10 L to 20 L of water per day. How would your life change if your access to water was reduced by 25%?

a. Complete the "Daily Log of Water Consumption" to calculate the amount of water you use weekly. A copy of this can be found as a handout on the Science 20 Textbook CD.



b. Calculate the total amount of water used.

c. Determine the amount of water available to you if you had to reduce the amount by 25%. Show your calculations.

DAILY LOG OF WATER CONSUMPTION

Activity	How Many Times Per Day							Amount of Water Used	Actual	Total
	M	T	W	T	F	S	S			
Bathroom										
flush toilet								20 L/flush		
shower								100 L/shower		
bath								150 L/bath		
brush teeth								10 L/brushing		
shave								20 L/shave		
Kitchen										
cook								20 L/meal		
wash dishes by hand								35 L/load		
use dishwasher								40 L/load		
use garbage disposal								20 L/use		
Utility Room										
use washing machine								225 L/load		
Outdoors										
wash car								400 L/car		
water lawn								500 L/lawn		
other								estimate		
Total Daily								Total Weekly		